



# MHD Modeling of Magnetospheric Compressions

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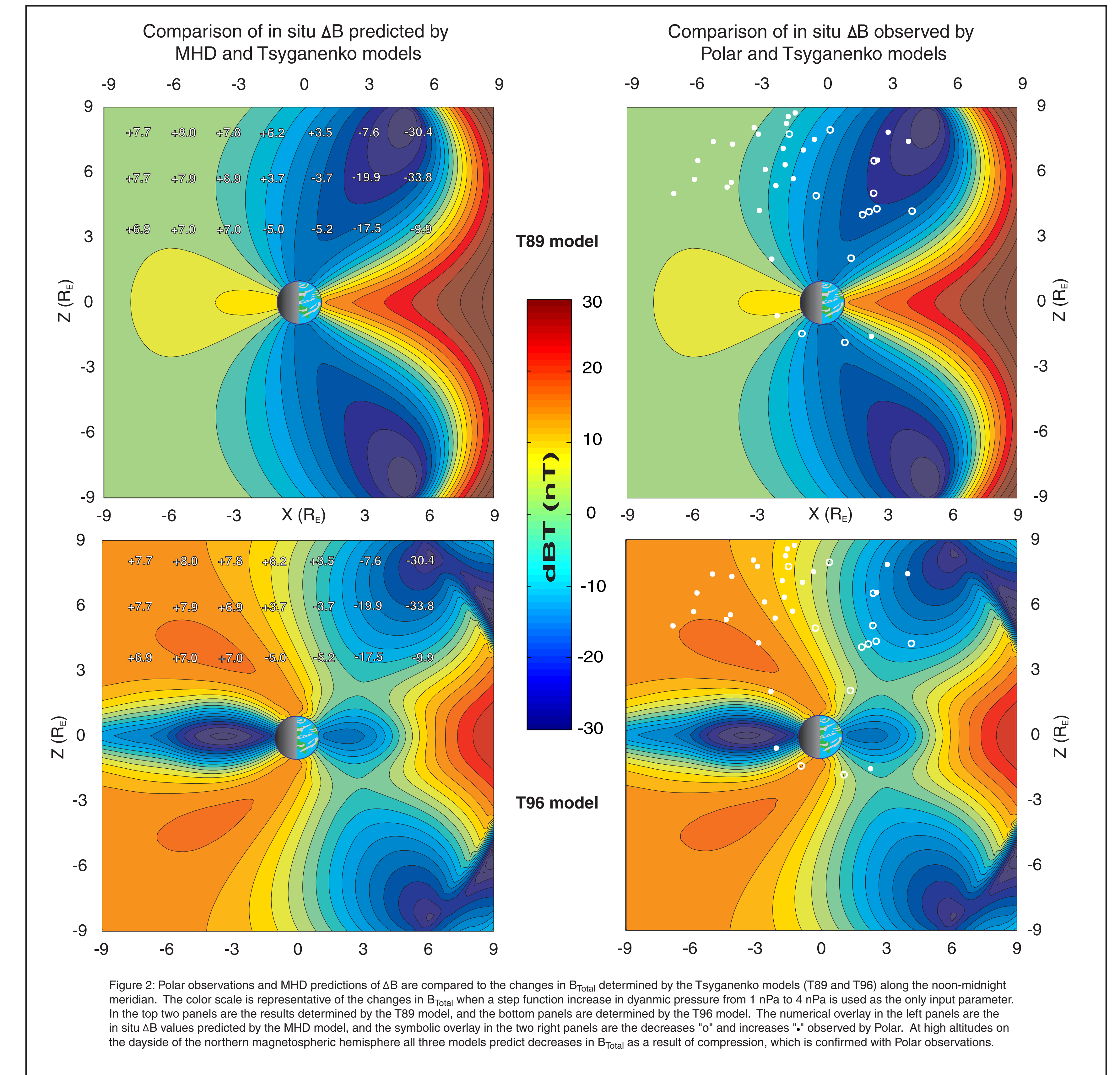
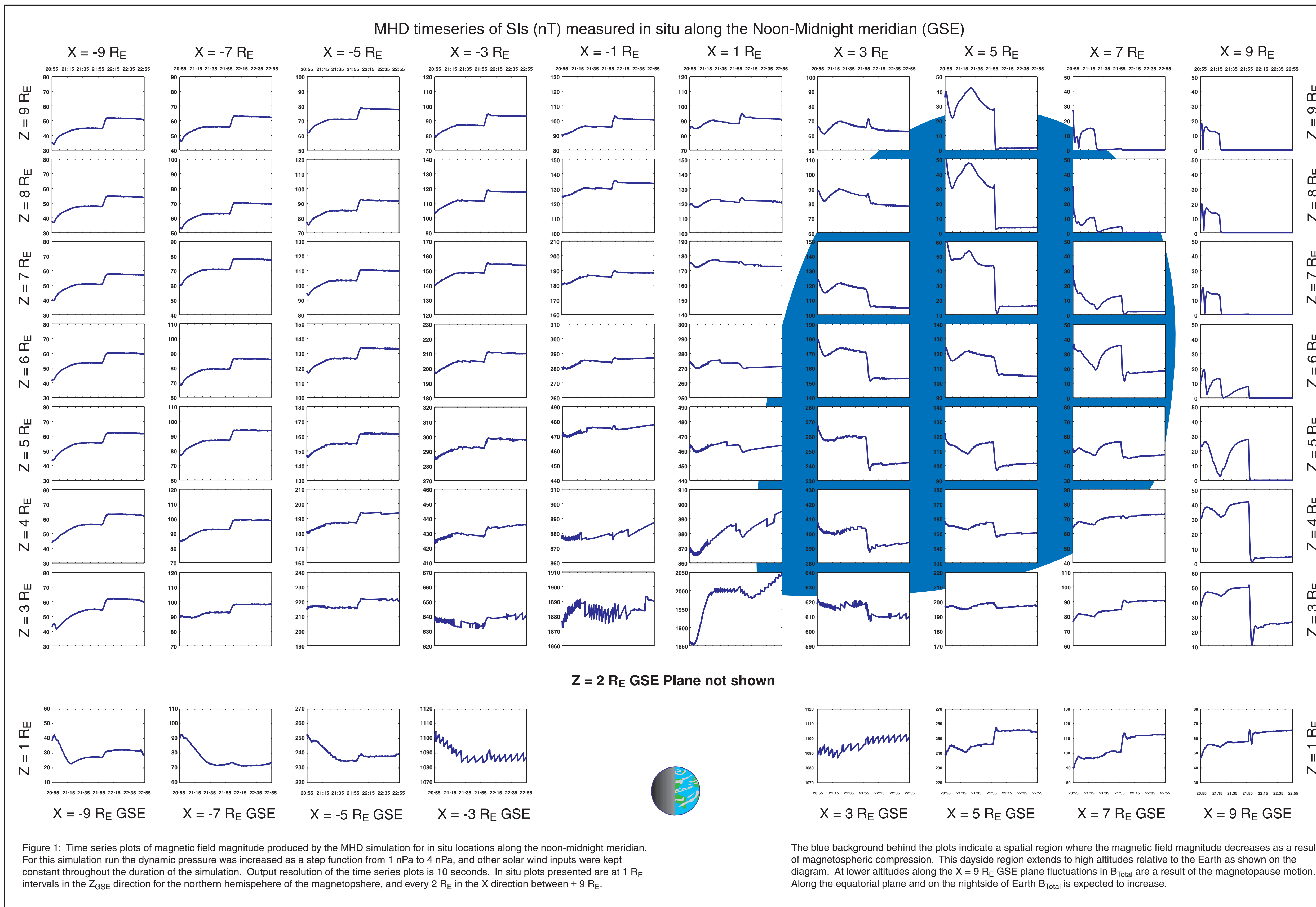
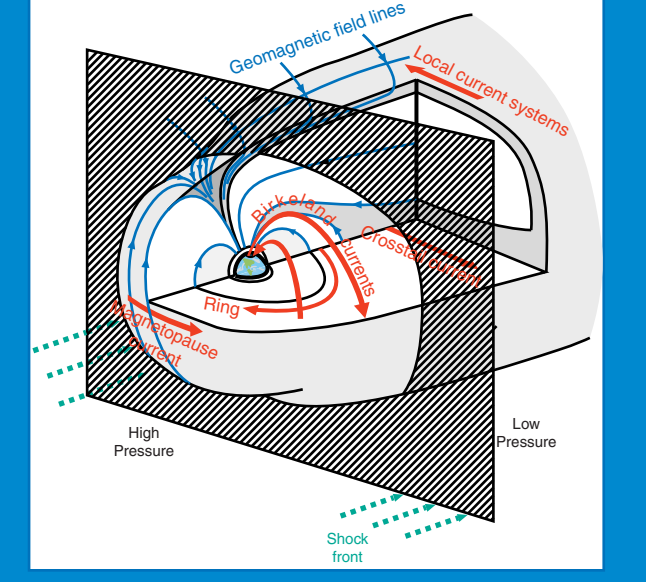
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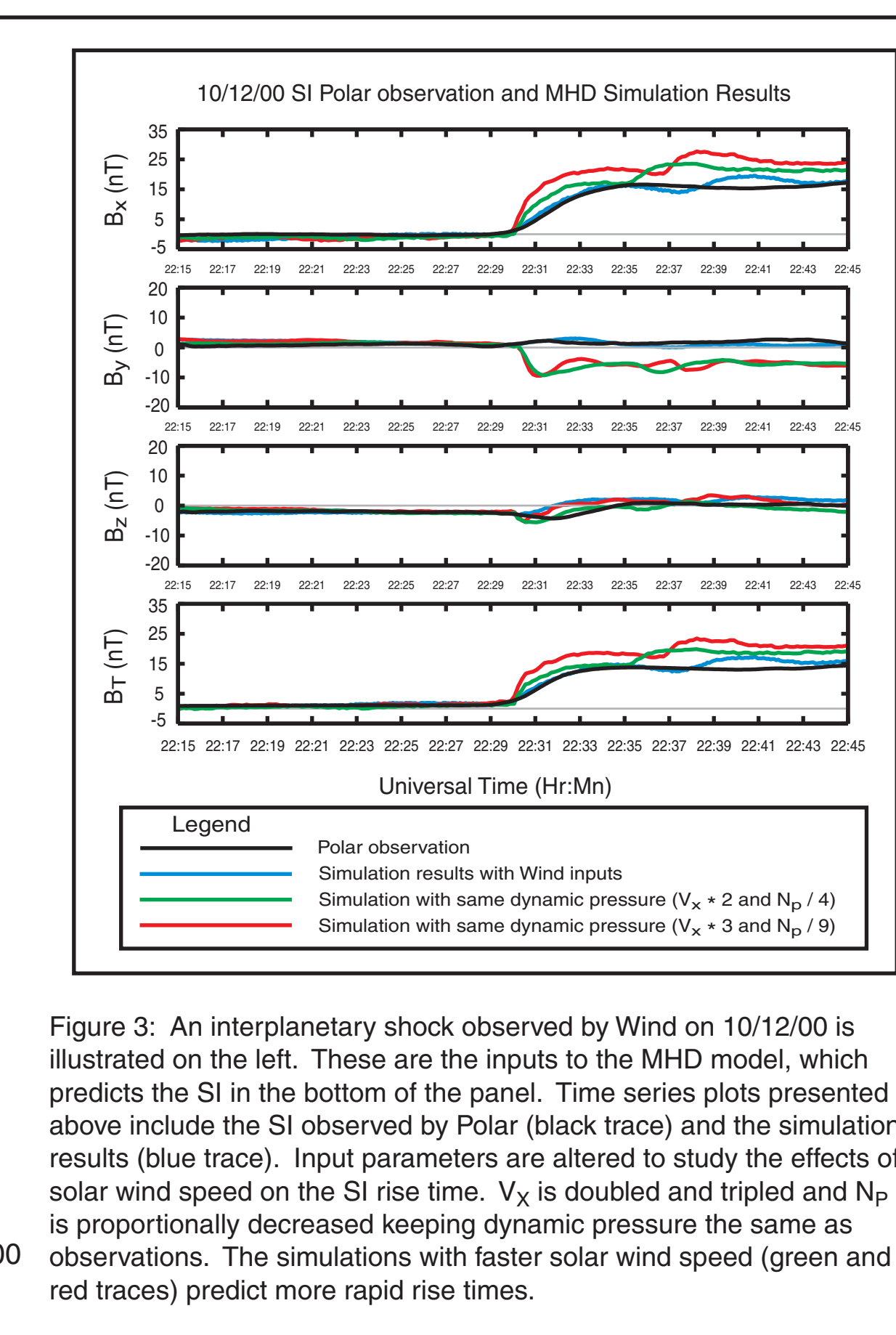
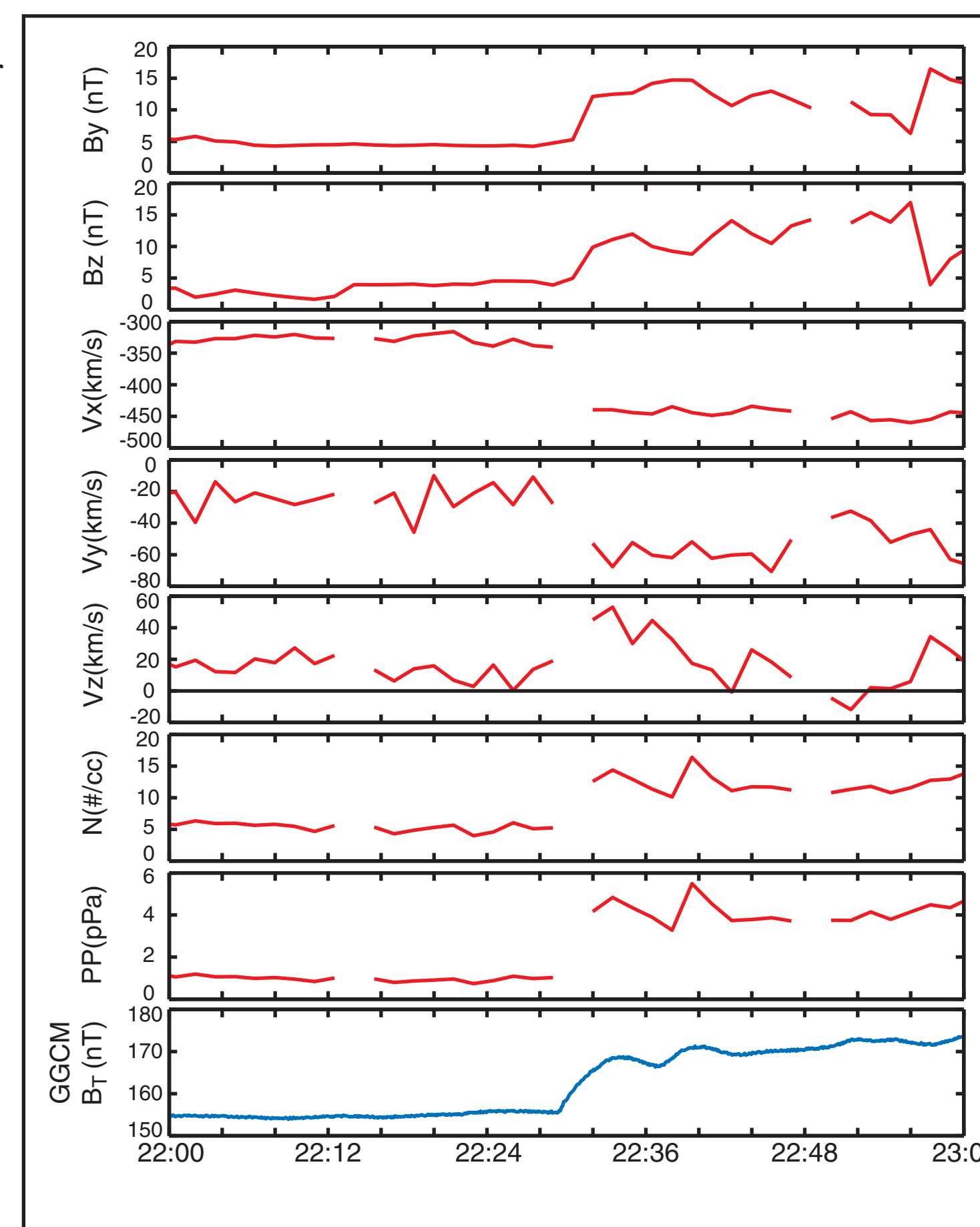
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**Abstract:** It is well known that dynamic pressure changes in the solar wind determine changes in the Earth's magnetic field. However, the magnetospheric response is not as rapid as the abrupt changes associated with a thin interplanetary shock front. We use an MHD model to investigate the rise time of sudden impulses (SIs) observed by the Polar spacecraft. By increasing the solar wind speed we see the magnetosphere response. Previous investigations with the T89 and T96 models have shown that at high altitudes on the dayside magnetospheric compression can lead to decreases in the magnetic field magnitude. Simulations with the MHD model predict similar responses, which is consistent with observations.

**Introduction:** Interactions between interplanetary shock fronts and the Earth's magnetosphere generates rapid enhancements in the geomagnetic field, which are known as a Sudden Impulses (SIs). These field enhancements maintain the pressure balance at the magnetopause between the Earth's magnetic fields and the solar wind dynamic pressure. Fowler and Russell [in preparation (a)] have investigated magnetospheric compression with the T89 and T96 models, and found that the models predict a high altitude region on the dayside where total magnetic fields decrease as a result of magnetospheric compression, which is consistent with observations. Fowler and Russell [in preparation (b)] have also used observational evidence to study the rise times of SIs, which is not possible with steady state models. The rise time is indicative of the duration that a compressional signal is measured in situ while the shock front propagates along the exterior of the magnetosphere. The rise time of an SI is dependent on the speed that a shock front travels through the solar wind.



**References:**  
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Raeder, J., Y. L. Wang, and T. J. Fuller-Rowell, Geomagnetic storm simulation with a coupled magnetosphere-ionosphere-thermosphere model, in *Space Weather*, ed. P. Song, H. Singer, and G. Siscoe, Geophysical Monograph Series, Vol 125, 2001.

**Acknowledgements:**  
Wind data were made available by K. W. Ogilvie and R. P. Lepping through CDA website. This work was supported by the National Aeronautics and Space Administration under research grant NAG5-7721.

**Results:** Magnetic field values are predicted throughout the magnetosphere with an MHD model that is fully described by Raeder et al., [2001]. Presented in Figure 1 are timeseries plots of a simulated SI where dynamic pressure was increased as a step function from 1 nPa to 4 nPa while all other inputs were kept constant. The plots are located in situ along the noon-midnight meridian as labeled in the figure. Highlighted by a blue backdrop is a region where  $B_{Total}$  decreases as a result of the compression. Contour plots are presented in Figure 2 that are magnetic field changes along the noon-midnight meridian determined by the T89 and T96 models. The color scale represents the magnitude of  $\Delta B$  where the hot colors are increases in  $B_{Total}$  and cool colors are decreases. Numerical overlays in the left column are the  $\Delta B$  values predicted by the MHD model from Figure 1, and the symbolic overlays in the right column of Figure 2 are the Polar observations within  $\pm 2 R_E$  of the noon-midnight meridian. In Figures 3 and 4 are MHD simulations of SIs observed by Polar on 10/12/00 and 9/28/96. Solar wind input speeds are modified to determine the effect on SI rise times. Dynamic pressure values are kept the same as the original Wind observations by adjusting  $N_p$ . Shock traveling faster in the solar wind produce SI with more rapid rise times, and slower speeds lead to a more prolonged SI rise time.

**Conclusions:** Results from MHD simulations of magnetospheric compression are presented. The magnetic field changes at high altitudes on the dayside are consistent with not only observations but also the T89 and T96 models when subjected to the same similar solar wind conditions. The MHD model well replicates two SI observations. Solar wind input speeds are increased and decreased for these SIs, which predicts faster and slower rise times respectively for the simulated SI.